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Performance of shrimp *Litopenaeus vannamei* submitted to different fasting periods

Desempenho do camarão *Litopenaeus vannamei* submetidos a diferentes períodos de restrição

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ABSTRACT

The aim of this study is to evaluate the effects of different fasting periods and refeeding on the growth of *Litopenaeus vannamei* shrimp. Groups of 15 animals (similar weight) were maintained in plastic tanks for 40 days and 3 treatments were imposed: daily feeding (control), 1 feeding day followed by 2 fasting days (2F) and 1 feeding day followed by 4 fasting days (4F) (n=6). On feeding days, overabundance food was offered in feeding trays and uneaten food removed after 12 h. Shrimp weight was measured every 10 days. Shrimp feed intake was higher in control group than in others, while specific growth rate (SGR) were higher for control and 2F groups, and lower for 4F group. However, the conversion of food into biomass (feeding efficiency) was significantly higher in 2F group than in 4F and control groups. Growth (weight gain/days) was similar amongst control and 2F groups and higher than 4F group. The results indicate that *L. vannamei* improves feed utilization when fed on the course of short starvation periods.

Keywords: Animal culture; *Litopenaeus vannamei*; Aquaculture; Food restriction.

RESUMO

O objetivo deste estudo é avaliar os efeitos de diferentes períodos de jejum sobre o crescimento do camarão *Litopenaeus vannamei*. Grupos de 15 animais (com peso semelhante) foram mantidos em

tanques plásticos por 40 dias e submetidos a 3 tratamentos: alimentação diária (grupo controle), 1 dia de alimentação seguido de 2 dias de jejum (2F) e 1 dia de alimentação seguido de 4 dias de jejum (4F) (n = 6). Nos dias de alimentação, a ração era oferecida nas bandejas de alimentação e o alimento não consumido era removido após 12 horas. Para acompanhar o crescimento, o peso dos animais foram medidos a cada 10 dias. O consumo de camarão foi maior no grupo controle do que em outros, enquanto a taxa de crescimento específico (SGR) foi maior nos grupos controle e 2F e menor no grupo 4F. No entanto, a conversão de alimentos em biomassa (eficiência alimentar) foi significativamente maior no grupo 2F do que nos grupos 4F e controle. O crescimento (ganho de peso / dias) foi semelhante entre os grupos controle e 2F e maior que o grupo 4F. Os resultados indicam que *L. vannamei* melhoram a utilização do alimento em períodos curtos de fome.

Palavras-chave: Cultivo de animais; *Litopenaeus vannamei*; Aquicultura; Restrição alimentar.

1 INTRODUCTION

Compensatory growth is defined as the fast growth that follows a fasting or reduced feeding period. Aquatic animals compensatory growth has been widely studied since 1970s (Weatherley and Gill 1987; Maclean and Metcalfe 2001; Broekhuizen et al. 1994; Bull and Metcalfe 1997), because of its implications for aquaculture, and also for the phenomenon biological understanding. In spite of this, literature is still very narrow on shrimp or any invertebrate.

Animals submitted to restricted food periods lose weight and decrease growth. When food is reestablished, those animals present hyperphagia and can achieve weight gain similar to fully fed controls (Maclean and Metcalfe 2001). Wu et al. (2001) observed complete catch up growth in groups of Chinese shrimp, *Fenneropenaeus chinensis*, submitted to periods of starvation and refeeding.

The animal's ability to acquire high quantity of food after fasting is an important factor to compensate growth (Hayward et al. 1997). Some shrimp species characteristically live in groups (Dall et al. 1990), and maintained in isolation show reduced appetite and growth performance (Ali et al. 2003). Shrimp are not aggressive animals and grouping may bring about interactions which are beneficial to increase food intake and also fitness. The absence of competition for food after fasting is extremely necessary for animals to achieve similar growth in large groups, as in aquaculture, a context in which shrimp are hold at high densities.

In view of the fact that more information is required about catch-up growth in shrimp, as well as the protocols that can be used to promote growth compensation in these animals, the aim of this study was to evaluate compensatory growth and feeding efficiency in *Litopenaeus vannamei* shrimp groups. Protocol similar to that of Hayward et al. (1997) and Nikki et al. (2004) were used, as the fasting periods varied in length and Hayward et al. (1997) reported overcompensation in growth.

2 MATERIALS AND METHODS

The experiment was carried out on juvenile *L. vannamei* shrimp and the animals (post-larvae) were obtained from LARVI Aquicultura Ltda – RN, Brazil, and reared in a nursery tank (volume 20000 L) for 1 month. After this period, shrimp were held in a stock tank (volume 500 L) at the laboratory of the Departamento de Oceanografia e Limnologia, UFRN, Natal-RN, Brazil, for a week until the beginning of the experiment. During this period of time shrimp were overfed once a day. For the experiment, groups of 15 shrimp (0.69 ± 0.09 g individual weight) were placed into plastic tanks (50 dm^3) filled with oxygen-saturated water ($\sim 8 \text{ mg/L}$), with low levels of ammonia ($<0.5 \text{ ppm}$) and nitrite ($<0.05 \text{ ppm}$), salinity at 5 ppm, and temperature of $25 \pm 1^\circ\text{C}$. The photoperiod was set from 0800 to 1800.

The shrimp groups were submitted to three different treatments: daily feeding (control), 1 feeding day followed by 2 fasting days (2F) and 1 feeding day followed by 4 fasting days (4F). Each treatment had six replicates. Food offered contained 35% crude protein (Purina® Ltda., Campinas, SP, Brazil). The experiment was carried on for 40 days.

Food was always offered in excess ($\sim 12\%$ tank biomass) and manipulated plastic plates were (200 cm^2) placed at the bottom of the tanks. After 12h, remaining food was removed, dried and weighted, supplying feed intake data. A previous test with food pellets showed that it does not leach or disintegrate before 24h in the water. Immediately after food was taken away, the period of fasting started. Shrimp was weighted before experimentation and each 10 days after that, totalizing 5 measurements. Growth was analyzed by specific growth rate [$\text{SGR} = (\ln \text{ final weight} - \ln \text{ initial weight}) * 100 / \text{time}$] and feeding efficiency [$\text{FE} = (\text{final weight} - \text{initial weight}) / (\Sigma \text{ food intake})$]. Data were compared by Anova or Kruskal-Wallis test, depending on the parametricity, followed by Tukey or Dunn's test, respectively.

Shrimp biomass (dependent variable) and time (independent variable) in each treatment were correlated using an exponential model ($y = ae^{bx}$). The dependent variables were neperian-logarithm-transformed and an analysis of covariance (Ancova) was carried out to compare slopes and intercepts of linear regressions.

3 RESULTS AND DISCUSSION

Initial weight of all groups did not differ among treatments: control $11.09 \pm 1.3\text{g}$, 2F $9.69 \pm 1.26\text{g}$ and 4F $10.20 \pm 1.45\text{g}$ (Anova, $F=1.7$, $P=0.21$). Following the fasting periods, shrimp groups did not present hyperphagia. Total feed intake during the experiment was statistically different among control ($73.38 \pm 8.79\text{g}$), 2F ($30.05 \pm 3.28\text{g}$) and 4F ($13.31 \pm 1.31\text{g}$) (Anova, $F=192.78$, $P < 0.001$) (Fig. 1).

The specific growth rate (SGR) was significantly higher in control (2.35 ± 0.47 g) and 2F (2.13 ± 0.12 g) than in 4F (0.81 ± 0.34 g) (Kruskal-Wallis, $H=11.78$, $P=0.003$) (Fig. 1). Feed efficiency (gain:feed) was statistically higher in 2F group (0.61 ± 0.04 g) than in control (0.34 ± 0.07 g) and 4F (0.39 ± 0.16 g) groups (Kruskal-Wallis, $H=11.15$, $P=0.001$).

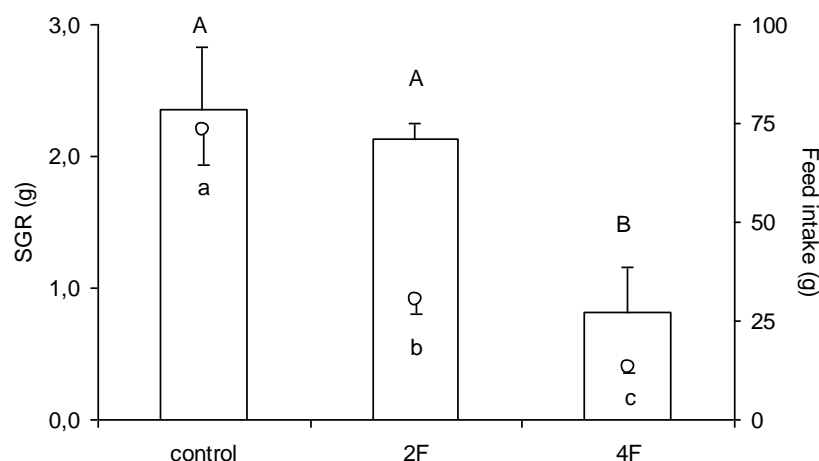


Figure 1. Fed intake and specific growth rate (SGR) of *L. vannamei* subjected to different fasting periods. Data are given as treatment means \pm sd ($n=6$). Bars indicate SGR and circles indicate fed intake. Treatments to which shrimp groups were submitted were: everyday feeding (control), 1 feeding day after 2 fasting days (2F) and 1 feeding day after 4 fasting days (4F). Different capital letters indicate statistical differences among SGR of different groups (Kruskal-Wallis, $P<0.05$). Different lower case letters indicate statistical differences between feed intake of different groups (Anova, $P<0.05$).

The linear regression slopes were not statistically different between control ($\text{LnC}=\text{Ln}2.37+0.028\text{days}$) and 2F groups ($\text{Ln2F}=\text{Ln}2.20+0.026\text{days}$) (Ancova, $F=0.85$, $P=0.36$), indicating similar weight gain ratio during the experimental period. However, both 2F and control groups were significantly different from 4F group ($\text{Ln4F}=\text{Ln}2.30+0.01\text{days}$) (control x 4F: Ancova, $F=47.07$, $P=0.0001$; 2F x 4F: Ancova, $F=41.02$, $P=0.0001$), which had the smallest weight gain ratio (Figure 2).

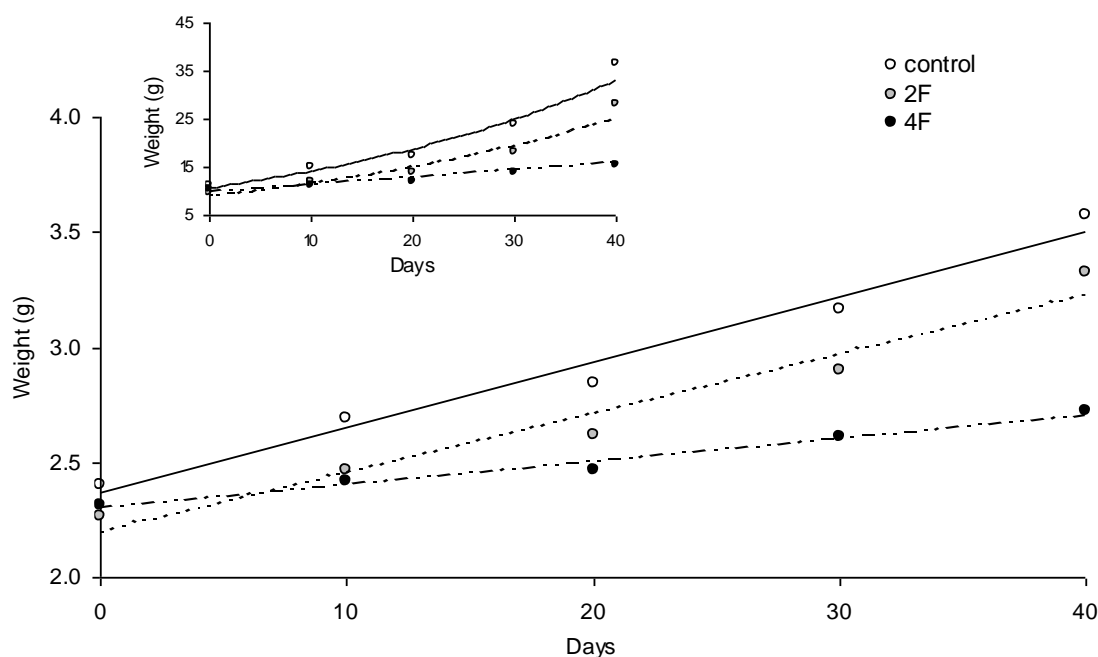


Figure 2. Weight of *L. vannamei* groups during 40 days subjected to different fasting and feeding periods. Small graph presents exponential growth equations and large graph presents exponential growth equations linearized. White circle is control group ($C = 10.72e^{0.028\text{days}}$, $\text{Ln}C = \ln 2.37 + 0.028\text{days}$), gray circle is 2F group ($2F = 9.05e^{0.026\text{days}}$, $\text{Ln}2F = \ln 2.20 + 0.026\text{days}$) and black circle is 4F group ($4F = 10.01e^{0.01\text{days}}$, $\text{Ln}4F = \ln 2.30 + 0.01\text{days}$). The linear regression slopes of control and 2F are similar (Ancova, $P > 0.05$) while slope of 4F is smaller than the other groups (Ancova, $P < 0.05$).

In this study shrimp group subjected to 2 fasting days intervals showed higher feeding efficiency than the other groups, and as much as daily fed groups, even when ingesting lower amount of food (Figure 1). Nevertheless feed intake was not as high as the control group, conversion of ingested food into biomass was significantly higher for the animals submitted to 2 starvation days animals, which indicates that short fasting periods may increase food absorption and utilization.

In terms of growth trajectory, the consequence of catch up growth is the achievement of a size similar to the size of an organism that has not experienced growth restrictions (Ali et al. 2003). The expression of full, partial or no compensation depend on many factors, such as nature, severity and duration of the under-nutrition, stage of developments of the organism and refeeding pattern (Wilson and Osbourn 1960; Ryan 1990).

The shrimp subjected to 2 fasting days period followed by 1 *ad libitum* feeding day (2F) showed SGR similar to control group. It indicates that there was a full compensatory growth response in 2F group, however it was not observed in 4F group (Figure 1). This result is in agreement with the study of Wu et al. (2001), who observed variation of catch up growth in Chinese shrimp depending

on the period of feed deprivation. Thus, it seems that the feeding pattern may regulate the growth power response in shrimp.

Other studies on the effects of starvation-realimentation on shrimp growth have shown that hyperphagia is the responsible mechanism for compensatory growth (Wu et al. 2000; Wu et al. 2001). On the contrary, at the present study shrimp did not increase food intake during refeeding, and thus, it appears that compensatory growth in *L. vannamei* was mainly dependent on improved feeding efficiency. Nonetheless, Wu and Dong (2002) observed that shrimp subjected to 30% protein restriction catch up growth due to improved feed conversion efficiency rather than increased food intake.

The results of the present study with *L. vannamei* shrimp appear to be in accordance with other results on shrimp species, in which there was not increased feed intake after a restriction period, but feeding efficiency increased to some extent (Shiau et al. 1991; Wu and Dong 2002). Hence, the regularity and extent of the realimentation phase may be the essential factor for the shrimp to catch up growth. Although the lack of comparative studies prevents deeper insights on this theme, the overview of the results discussed above on SGR, food intake and feeding efficiency indicates that 2 fasting days followed by 1 feeding day promote better food conversion than continuously feeding or 4 fasting days and 1 feeding day. This data allows the suggestion that repetitive fasting and feeding cycles may be a useful protocol to improve feeding utilization and promote better productivity in shrimp aquaculture. It is, therefore, needed further investigations on nutrients digestibility and/or longer periods of refeeding to elucidate other aspects of these animals physiology and growth.

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